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Molecular vacuum pump

So as to obtain for a molecular vacuum pump, which is designed on the high vacuum side as a turbomolecular vacuum pump, a better pre-vacuum steadiness, it is suggested to provide at least a portion of the pump active surfaces on the pre-vacuum side as an annular disk (7) with channel-like openings (14, 14'), which penetrate the plane of the disk in an oblique manner.

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Molecular vacuum pump

CLAIMS

1. A molecular vacuum pump, which is designed at the high vacuum side as a turbomolecular vacuum pump,
   characterized in that at least a portion of the pump active surfaces at the pre-vacuum side are designed as an annular disk (7) having channel-like openings (14, 14'), which penetrate the plane of the disk in an oblique manner.

2. The pump of claim 1, characterized in that at least a portion of the pump active surfaces, provided subsequent to the transition from the molecular flow to the laminar flow, are designed according to claim 1.

3. The pump of claim 1 or 2, characterized in that the pump active surfaces of the pre-vacuum side area of the rotor (3) and/or the stator (2) are designed according to claim 1 or 2.

4. The pump of one of the preceding claims, characterized in that the axis (15, 15') of the channel-like openings (14, 14') form with regard to the plane of the disk an angle α between 5° and 40°.

5. The pump of one of the preceding claims, characterized in that the projections of the axis (15, 15') of the openings (14, 14') of the disk extend tangentially in the penetration point onto the plane of the disk.

6. The pump of one of claims 1 to 4, characterized in that the projections of the axis (15, 15') of the openings (14, 14') onto the plane of the disk form with the tangent in the penetration point an angle β with $0° < \beta \leq 40°$.

7. The pump according to claim 6, c h a r a c t e r i z e d i n t h a t the directions of the axes correspond to the direction of the flow of gas and point, for the stator disk (7), inwardly and ,for the rotor disk (7'), outwardly.

8. The pump according to one of the preceding claims, c h a r a c t e r i z e d i n t h a t the width of the annular disk sections (13, 13') corresponds in substance to the length of the vanes (12) of the stages of the turbomolecular vacuum pump on the high vacuum side, and that the width of the channel-like openings (14, 14') is approximately 1/2 to 1/5 of the width of the annular disk.

9. The pump of claim 8, c h a r a c t e r i z e d i n t h a t there are provided two or more concentric rows (18, 19, 20) of channel-like openings (14, 14').

10. The pump of claim 8 or 9, c h a r a c t e r i z e d i n t h a t on the circumference of the annular disk one channel-like opening and a pair of channel-like openings are arranged in an alternating manner.

11. The pump of one of the preceding claims, c h a r a c t e r i z e d i n t h a t a part of the openings (14) are open towards the inner side, and a part of the openings (14') are open laterally towards the outer side.

12. The pump of one of the preceding claims, c h a r a c t e r i z e d i n t h a t the channel-like openings (14, 14') are made by stamping.

13. The pump of one of the preceding claims, c h a r a c t e r i z e d i n t h a t the openings (14, 14') are designed with respect to the axes (15, 15') similar to nozzles.

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Molecular vacuum pump

The invention relates to a molecular vacuum pump, which is designed on the high vacuum side as a turbomolecular vacuum pump.

In the book of Wutz, Adam and Walcher "Theorie und Praxis der Vakuumtechnik", Vieweg-Verlag, 1981, p. 202 and the following, the known types of molecular vacuum pumps are described. For the first designs, the pump active surfaces had a cylindrical shape. Later molecular pumps according to Holweck and Siegbahn had pump surfaces designed partially as screws or as a spiral-shaped groove. Said older molecular pump types had a low suction capability and were difficult to manufacture because extremely small gaps were needed between the non-rotating and the rotating surfaces. Then, a generation of turbomolecular vacuum pumps followed, where the pump active surfaces were designed according to a turbine, i.e. they used interdigiting stator and rotor vane rows. This prior art has to be supplemented by the contents of DE-OS 24 12 624, which describes a molecular vacuum pump designed on the high vacuum side as a turbomolecular vacuum pump, and at the pre-vacuum side as a screw pump. The disadvantages of the Holweck and Siegbahn pumps are again present with the pre-vacuum side area.

Turbomolecular vacuum pumps have the disadvantage that a safe and effective operation is, in principle, only then guaranteed, if on the pre-vacuum side a pressure of 10^{-2} to 10^{-3} mbar exists. This requires a relatively high expense for the creation of the pre-vacuum.

The present invention thus deals with the problem to reduce the expense for the generation of a pre-vacuum for one of the molecular vacuum pumps mentioned initially.

This problem is solved for a molecular vacuum pump, designed on the high vacuum side as a turbomolecular pump, by designing at least a portion of the pre-vacuum side pump active surfaces as an annular disk with channel-like openings, which obliquely penetrate the plane of the disk. Either the stator or the rotor or both can be designed in this manner. It is desirable to provide for the design of the pump active surfaces in accordance with the invention at locations, where the molecular flow characteristics of the gases to be pumped are no longer present, i.e. locations, where the average free path length of the molecules of the pumped gases is small with respect to the vane spacing.

By to the features of the invention, the radial flows in the space between the vanes are reduced and by means of the long and flat inflow path of the gases, a better interaction with the gas flow profile created by the rotor is obtained. Such a gas guidance system is, with regard to the interaction of the oppositely located surfaces, comparable with the friction molecular pumps, but can transport significantly larger amounts of gas. Overall, a significant improvement of the compression capability in the pre-vacuum side section of the pump results, such that the pre-vacuum pressure can be substantially higher. The expense for the apparatus for creating a pre-vacuum can thus be respectively reduced.

Further advantages and details of the invention will be described in connection with Figs. 1 through 7, which show embodiments of the invention.

Fig. 1 discloses a portion of a sectional view of a molecular vacuum pump of the invention comprising a housing 1, the stator 2, and the rotor 3. The housing 1 is provided at the high vacuum side with a flange 4. Flange 4 is adapted to be connected with a recipient, not shown, in which the high vacuum is to be created by means of the turbomolecular vacuum pump as shown. On the pre-vacuum side, the housing is provided with a port tube 5 to which the pre-vacuum pump, not shown, can be connected. The stator 2 comprises on the high vacuum side vane rings 6 and at the pre-vacuum side annular disks 7 designed according to the invention, which are respectively spaced by spacer rings. The vane rings 6 and the annular disks 7 each comprise a section 8 and 9, respectively, which is located between the spacer rings. The sections 8 of the vane rings 6 comprise inwardly directed vanes 11. The spaces be-

tween said vanes 11 formed due to said spacer rings are in engagement with the vanes 12 connected to the rotor 3 and form together with the stator means 11 the pump stage located on the high vacuum side, and being designed as a turbo-molecular vacuum pump.

The sections 9 of the annular disks 7 on the vacuum side continue inwardly with their pump active surfaces 13, which comprise channel-like openings 14, which obliquely penetrate the annular disks 7. The disk sections 13 with the openings 14 form together with the vanes 12 the rotor the pump stage, which is located on the pre-vacuum side. Within the framework of the invention it is possible to replace in this area also the vanes 12 of the rotor 3 by pump active surfaces, which could be of the same design as the pump active surfaces of the stator 2, i.e. as annular disks with oblique or inclined penetrating openings.

Naturally, also the pump active surfaces of the rotor could be designed in this manner (see the rotor annular disk 12' in Fig. 1).

Figs. 7 and 8 disclose another possibility of design for the openings 14 (or also 14'). They are shaped like a nozzle. This form can also be realized by stamping with respectively designed stamping tools.

For the subject matter of the invention, the pump active surfaces of the rotor 3 can be formed by the customary vane rows (vanes 12). However, it is desirable to use in the pre-vacuum area annular disks 12', which comprise openings 14' corresponding to the openings 14 of the stator ring disks 3. Fig. 1 shows, only as an example, such a rotor ring disk 12'. With regard to the design of the openings 14', attention is drawn to the description of Figs. 3 and 6.

Figs 2 and 3 show a portion of an annular or ring disk 7 with its annular or ring sections 9 and 13 in a top plan view, and a developed side elevational view. The ring section 13 is provided with openings 14, which penetrate the plane of the ring disk 7 in an oblique manner. Preferably, the manufacture of said openings 14 is carried out such that the respective hatched area in Fig. 2 is - with respect to the plane of the drawing - drawn downwardly, and the unhatched area is pressed outwardly out of the

disk 7, such that the opening 14 is created with an axis 15 extending obliquely with respect to the plane of the disk. The axes 15 form together with said plane of the ring disk 7 an angle α (Fig. 3), the size of which is desirably between 5° and 40°. With regard to the selection of said positional angle α somewhat similar is true as is with respect to the positional angle of the rows of vanes. The closer the openings 14 are to the pre-vacuum side, the smaller should be the positioning angle α.

From the top plan view (Fig. 2) it is clear that the projections of the axis are tangentially on the disk plane, i.e. the planes of the openings 14 are positioned essentially radially. The direction of rotation of the immediately adjacent pump active surfaces of the rotor, which can be designed as vanes 12, or which can also comprise the channel-shaped openings, is characterized by the arrow 16. A rotor ring disk 7' with channel-like openings 14' is additionally shown in Fig. 3. The inclination of the axis 15', i.e. the positional angle α corresponds to the values of the adjacent stator ring disk 7. The transport direction is characterized by the arrow 17.

The embodiment shown in Figs. 4 and 5 corresponds largely to the embodiment shown in Figs. 2 and 3. The only difference is that the axes 15 of the channel-like openings 14 no longer extend tangentially. Their projection onto the plane of the disk 7 forms with the respective tangents, which extend through the respective sectional points of the axis 15 with the disk plane, an angle β such that the axes 15 - seen in the direction of rotation of the adjacent pump active surface of the rotor - extend from the outside towards the inside. The size of the angle β can be between 0 and 40°; preferably the size is 25°. The pump active surfaces of the rotor can be designed in this manner. The directions of the axes 15 (and 15', respectively) need to correspond to the flow of gas and must point for the stator disk 7 inwardly, and for the rotor disk 7' outwardly.

The described channel-like openings 14 can be formed by stamping of a ring disk 7 preferably made of aluminum. For the embodiment of Figs. 2 through 4, the openings 14 have a substantially round cross section.

For the embodiment of Fig. 6, the openings 14 are selected such that they have a shape or form deviating from the circular form in the direction of a square or a rec-

tangular shape. Further, altogether three concentric rows 18, 19, 20 are provided on the ring section 13. Alternatingly a pair of adjacently located openings 14 is followed by an individual opening in a row 19, which is located inbetween. The width of the openings 14 is selected such that it is smaller than half of the width of the ring or annular disk section 13. The width of the inner row of openings 14 is about 1/4 of the width of the ring disk section 13. Moreover, the inwardly located openings 14 are designed such that they are open laterally towards the inner side. The assignment of the openings 14 with respect to each other is shown with respect to their axes 15, which are, seen from the side, shown on three developed circular rows.

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Turbomolecular pump

The invention relates to a turbomolecular pump with a stator consisting of rings and housed in a housing, and a rotor cooperating with the stator.

Stators of turbomolecular pumps are regularly constructed in the manner that rings comprising inwardly facing blades and spacer rings are disposed alternately on top of each other (see for example DT-OS 1 428 239). Rotor blades engage in the spaces formed by the spacer rings. The set consisting of spacer rings and blade rings is centered by the inner wall surface of the housing of the turbomolecular pump.

Such a construction of the stator of a turbomolecular pump requires very exact machining on the inner wall of the housing and the outer surfaces of the spacer rings, which is expensive and costly. For if the rings do not fit closely to the housing, a significant back-flow of gas takes place in the gap formed by the stator and the housing, which interferes considerably with the performance of the turbomolecular pump. Furthermore it is not guaranteed anymore that the many independent rings are centered.

Thus, the spacer rings of the turbomolecular pump known from DT-OS 2 046 745 are formed as piston rings, i.e. are split in one location and spread apart outwardly, so that they can adapt to possible irregularities of the inner wall surface of the housing. This solution, too, requires exact machining on the inner wall surface of the housing, since on the one hand the irregularities must not be so strong that adaption is not possible anymore, and on the other hand the inner wall surface must still assume the function of centering the blades in the housing. Finally, a back-flow of the gases through the gaps of the split spacer rings is not eliminated with this solution.

It is the problem of the invention to position the stator of a turbomolecular pump in a housing such that exact machining on the inner wall surfaces of the

housing is no longer required and that a back-flow of gases aggravating the vacuum in the pump does not take place anymore.

According to the invention this problem is solved with a turbomolecular pump having a stator consisting of rings and housed in a housing, and a rotor cooperating with the stator, by the stator being formed as a self-centering unit independent from the housing, and by seal rings being provided between the stator unit and the inner wall of the housing. Since the inner wall surface of the housing does not have to assume the centering of the stator pump anymore in a turbomolecular pump formed in this manner, neither the inner wall surface nor the outer surfaces of the rings have to be machined exactly. The seal rings formed for instance from flexible plastics are able to adapt themselves to greater irregularities, such that no back-flow of gases takes place anymore.

An advantageous feature according to the invention consists in that the stator consists of blade rings and spacer rings disposed alternately on top of each other in a known manner, and that several bolts are provided for mutual centering of the rings. Especially advantageous, however, proved to be the feature that the spacer rings are formed as profile rings centering themselves and the blade rings. With a stator formed in such a manner the bolts are not needed anymore. Cohesion of the rings is achieved by the housing being slid on.

Further advantages and details of the invention are to be explained with reference to the embodiments illustrated in figs. 1 to 3.

The figures each show a partial sectional view through a turbomolecular pump constructed according to the invention, which consists of the housing 1, the stator 2 and the rotor 3. The housing 1 is provided with the flanges 4 and 5, which serve for the connection with a recipient not shown (flange 4) and a bottom plate of the pump likewise not shown (flange 5). The stator 2 consists of blade rings 6 and spacer rings 7 disposed alternately on top of each other.

The blades 8 of the blade rings 6 are faced inward, and the rotor blades 9 connected with the rotor 3 engage in the spaces between the blades 8 formed by the spacer rings.

In order to center the stator package 2 independently from the housing 1, several bolts 10 are provided in the embodiment of fig. 1 (only one of them is shown). These bolts cause the blade rings and the spacer rings to be pressed together at the same time. In order to avoid a back-flow of gases in the ring gap formed by the housing 1 and the stator package 2, seal rings 11, 12, and 13 are provided. At the level of the seal rings the beads 14, 15, and 16 are provided in the housing effecting a firm fit of the seal rings.

In the embodiment in fig. 2 the spacer rings 7 are formed as profile rings having a centering nose or tab 17 and a recess 18. Thus, the rings of the stator unit 2 can be disposed in relation to each other such that each centering nose 17 engages in the recess 18 of the adjacent spacer 18, and that the outer surface of the blade ring 6 adjoins the centering nose 17. Thereby a centering of the stator package 2 independent from the housing 1 is achieved.

In the embodiment of fig. 3 the spacer rings 7 comprise two recesses 19 and 20. Another centering ring 21, which adjoins the outer surface of the blade ring 6, engages in the annular groove formed by two spacer rings 7 with their respective recesses 19 and 20. This arrangement, too, effects centering of the stator package 2 independent from the housing 1.

Claims

1. Turbomolecular pump having a stator consisting of rings and housed in a housing, and a rotor cooperating with the stator, characterized in that the stator (2) is formed as a self-centering unit, independent from the housing (1), and that seal rings (11, 12, 13) are provided between the stator (2) and the inner wall of the housing (1).

2. Turbomolecular pump according to claim 1, characterized in that the stator (2) consists of blade rings and spacer rings (6, 7, respectively) disposed alternately on top of each other in a known manner, and that several bolts (10) are provided for centering the rings (6, 7).

3. Turbomolecular pump according to claim 1, characterized in that the spacer rings (7) are formed as profile rings centering themselves and the blade rings (6).

4. Turbomolecular pump according to claim 3, characterized in that the spacer rings (7) are formed as profile rings having a centering nose (17) and a recess (18), and that the rings (6, 7) of the stator unit are disposed in relation to each other such that each centering nose (17) engages in the recess (18) of the adjacent spacer, and that the outer surface of the blade ring (6) adjoins the centering nose (17).

5. Turbomolecular pump according to claim 1, characterized in that the spacer rings (6) comprise two recesses (19, 20), with another centering ring (21) engaging therein, the outer surface of the blade ring (6) abutting said centering ring (21).

6. Turbomolecular pump according to one of the preceding claims, characterized in that at least three seal rings (11, 12, 13), preferably O-rings, are provided between the stator (2) and the housing (1).

7. Turbomolecular pump according to one of the preceding claims, characterized in that beads (14, 15, 16) are provided in the housing at the level of the seal rings (11, 12, 13).